Year: 2021

Can individual, dyadic, or collaborative planning reduce sedentary behavior? A randomized controlled trial

Szczuka, Zofia ; Kulis, Ewa ; Boberska, Monika ; Banik, Anna ; Kruk, Magdalena ; Keller, Jan ; Knoll, Nina ; Scholz, Urte ; Abraham, Charles ; Luszczynska, Aleksandra

Abstract: RATIONALE: Although effects of individual planning interventions on physical activity (PA) are well established, less is known about the relationships between planning and sedentary behavior (SB). OBJECTIVE: This study evaluated the efficacy of individual planning, dyadic planning (i.e., joint planning, targeting the behavior of one person only: the target person), and collaborative planning (i.e., joint planning and joint behavioral performance) on sedentary behavior among dyads. METHODS: Dyads (N = 320 target persons and their partners, aged 18-90 years) were randomized into three PA planning conditions (individual, dyadic, or collaborative) or an active (education) control condition. Main outcomes, i.e., sedentary time, proportion of time spent in SB and light-intensity PA, proportion of time spent in SB and total PA were measured with GT3X-BT accelerometers at baseline, 1-week follow-up, and 36-week follow-up. Two-level models with measurement points nested in participants were fit, separately for target persons and partners. RESULTS: Findings for target persons obtained at 1-week follow-up indicated that in the collaborative planning condition SB time significantly decreased, compared to the control condition (p = .013). There was an improvement in the proportion of time spent in SB and light-intensity PA (p = .019), and the proportion of time spent in SB and total PA (p = .018), indicating that SB time was displaced by PA. Effects of individual and dyadic planning were not significant, compared to the control condition. None of interventions had a significant effect on SB indices at 36-week follow-up. Regarding dyadic partners, there were no effects of planning interventions at 1-week follow-up or 36-week follow-up, compared to the control condition. CONCLUSIONS: Collaborative planning may prompt a short-term reduction of SB time and result in a shift towards a healthier balance between SB time and PA time among target persons, who did not adhere to PA guidelines at baseline.

DOI: https://doi.org/10.1016/j.socscimed.2021.114336

Szczuka, Zofia; Kulis, Ewa; Boberska, Monika; Banik, Anna; Kruk, Magdalena; Keller, Jan; Knoll, Nina; Scholz, Urte; Abraham, Charles; Luszczynska, Aleksandra (2021). Can individual, dyadic, or collaborative planning reduce sedentary behavior? A randomized controlled trial. Social Science Medicine, 287:114336.
DOI: https://doi.org/10.1016/j.socscimed.2021.114336

Social Science & Medicine 287 (2021) 114336

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Can individual, dyadic, or collaborative planning reduce sedentary behavior? A randomized controlled trial☆

Zofia Szczuka [a,*], Ewa Kulis [a], Monika Boberska [a], Anna Banik [a], Magdalena Kruk [b], Jan Keller [c], Nina Knoll [c], Urte Scholz [d], Charles Abraham [e], Aleksandra Luszczynska [a,f,**]

[a] Wroclaw Faculty of Psychology, SWPS University of Social Sciences and Humanities, Aleksandra Ostrowskiego 30b, 50505, Wroclaw, Poland
[b] Institute of Psychology, University of Wroclaw, Dawida 1, 50529, Wroclaw, Poland
[c] Department of Education and Psychology, Freie Universität Berlin, Habelschwerdter Allee 45, 14195, Berlin, Germany
[d] Applied Social and Health Psychology, University Research Priority Program "Dynamics of Healthy Ageing", Department of Psychology, University of Zurich, Binzmuehlestrasse 14, 8050, Zurich, Switzerland
[e] School of Psychology, Deakin University, 1 Gheringhap St, Geelong, VIC, 3220, Australia
[f] Melbourne Centre for Behavior Change, Melbourne School of Psychological Sciences, University of Melbourne, Redmond Barry Building, Parkville Campus, Melbourne, VIC, 3010, Australia

ARTICLE INFO

Keywords:
Sedentary behavior
Planning
Dyads
Physical activity
Randomized controlled trial

ABSTRACT

Rationale: Although effects of individual planning interventions on physical activity (PA) are well established, less is known about the relationships between planning and sedentary behavior (SB).
Objective: This study evaluated the efficacy of individual planning, dyadic planning (i.e., joint planning, targeting the behavior of one person only: the target person), and collaborative planning (i.e., joint planning and joint behavioral performance) on sedentary behavior among dyads.
Methods: Dyads ($N = 320$ target persons and their partners, aged 18–90 years) were randomized into three PA planning conditions (individual, dyadic, or collaborative) or an active (education) control condition. Main outcomes, i.e., sedentary time, proportion of time spent in SB and light-intensity PA, proportion of time spent in SB and total PA were measured with GT3X-BT accelerometers at baseline, 1-week follow-up, and 36-week follow-up. Two-level models with measurement points nested in participants were fit, separately for target persons and partners.
Results: Findings for target persons obtained at 1-week follow-up indicated that in the collaborative planning condition SB time significantly decreased, compared to the control condition ($p = .013$). There was an improvement in the proportion of time spent in SB and light-intensity PA ($p = .019$), and the proportion of time spent in SB and total PA ($p = .018$), indicating that SB time was displaced by PA. Effects of individual and dyadic planning were not significant, compared to the control condition. None of interventions had a significant effect on SB indices at 36-week follow-up. Regarding dyadic partners, there were no effects of planning interventions at 1-week follow-up or 36-week follow-up, compared to the control condition.
Conclusions: Collaborative planning may prompt a short-term reduction of SB time and result in a shift towards a healthier balance between SB time and PA time among target persons, who did not adhere to PA guidelines at baseline.

☆ This study was supported by grant no. 2014/15/B/HS6/00923 from National Science Centre, Poland, awarded to Aleksandra Luszczynska. The scientific work of Zofia Szczuka was financed from the budget funds for science in the years 2016-2019 as a research project within the framework of "Diamond Grant" (Diamentowy Grant).

* Corresponding author. Wroclaw Faculty of Psychology, SWPS University of Social Sciences and Humanities, Ostrowskiego 30b, 53-238, Wroclaw, Poland.
** Corresponding author. Wroclaw Faculty of Psychology, SWPS University of Social Sciences and Humanities, Ostrowskiego 30b, 53-238, Wroclaw, Poland.
E-mail addresses: zszczuka@swps.edu.pl (Z. Szczuka), ekulis@swps.edu.pl (E. Kulis), mboberska@swps.edu.pl (M. Boberska), abanik@swps.edu.pl (A. Banik), mkruk@swps.edu.pl (M. Kruk), jan.keller@fu-berlin.de (J. Keller), nina.knoll@fu-berlin.de (N. Knoll), urte.scholz@psychologie.uzh.ch (U. Scholz), c.abraham@deakin.edu.au (C. Abraham), aluszczy@uccs.edu (A. Luszczynska).

https://doi.org/10.1016/j.socscimed.2021.114336
Received 23 March 2021; Received in revised form 27 July 2021; Accepted 19 August 2021
Available online 21 August 2021

1. Introduction

Sedentary behavior (SB) can be defined as any waking activity characterized by an energy expenditure ≤1.5 METs while in a sitting, lying, or reclining posture (Tremblay et al., 2017). SB has become prevalent across domains of human activity as a result of changes in transportation, communications, workplace, and domestic entertainment technologies (Owen et al., 2020). One in five Europeans sit for more than 7.5 h each day (Loyen et al., 2016). High levels of SB are associated with an increased risk of chronic diseases, such as fatal and non-fatal cardiovascular disease, metabolic syndrome, type 2 diabetes, and lower physical quality of life (Boberska et al., 2018; De Rezende et al., 2014). The population-attributable mortality fraction estimated across 54 countries suggest that SB time may be responsible for approximately 433,000 deaths/year, representing 3.8% of all-cause mortality (De Rezende et al., 2016). The World Health Organization (WHO) recommends that adults should limit the amount of SB and replace it with physical activity (PA) of any intensity to help reduce its detrimental effects on health (WHO, 2020).

SB, light-intensity physical activity (LIPA), and moderate-to-vigorous physical activity (MVPA) are interrelated or co-dependent behaviors (van der Ploeg and Hillsdon, 2017): reducing one often means incorporating more of the other behavior during the waking hours. SB, LIPA, and MVPA all refer to energy expenditure, the key difference between them referring to the levels of energy expended. Time spent on one naturally displaces time spent on another (referred to as the *displacement hypothesis*; Matthews et al., 2015). For instance, time spent on SB may be replaced by time spent on stretching, aerobic, or strength exercises. In line with the displacement hypothesis, interventions targeting a reduction of SB time are suggesting to ‘sit less, stand up, and move more’ (Owen et al., 2020). Even replacing SB for a short time (e.g., 1–10 min) may be associated with a reduced likelihood of metabolic syndrome (Ekblom-Bak et al., 2016).

Since they may displace one another, it makes sense to assess SB, LIPA, and MVPA simultaneously (Hamilton et al., 2008; Matthews et al., 2015), and consider ratios of SB versus LIPA (including such activities as standing, stretching), or SB time versus total PA time (LIPA + MVPA). Such approach may offer an insight into a healthy energy expenditure balance, characterized by less SB time and more LIPA or MVPA time (Spittaels et al., 2012).

Replacing time spent on SB with bouts of PA may require not only strong intentions (Gollwitzer and Crosby, 2018; Hagger et al., 2016), but also post-intentional self-regulatory efforts (Sheeran and Webb, 2016). Theoretical models, such as the health action process approach (Luszczynska and Schwarzer, 2020), suggest that planning is one of the key post-intentional predictors of behavior change. The formulation of action plans (referring to when, where, and how the individual will act) and coping plans (specifying actions to be taken if obstacles to action plans are encountered) are critical to the enactment of intentions (Luszczynska and Schwarzer, 2020).

The use of planning to promote PA has been thoroughly investigated (Bélanger-Gravel et al., 2013; Carraro and Gaudreau, 2013; Silva et al., 2018; Zhang et al., 2019) but less is known about the effects of planning on SB time reduction. The existing SB-related evidence evaluates the effects of individual planning only (De Cocker et al., 2016; Maher and Conroy, 2015; Rollo and Prapavessis, 2020; Schroé et al., 2020), without considering the social context of planning. Research including significant others in the individuals’ specific action planning and ‘if-then’ planning is needed (Hagger et al., 2016), as significant others are often involved in health behavior change (Lüscher et al., 2019; Scholz et al., 2020). The present study will investigate whether individual planning and two forms of planning involving social interactions (i.e., dyadic and collaborative planning) influence SB.

Dyadic and collaborative planning refer to target persons forming plans together with a partner (Keller et al., 2020; Knoll et al., 2017). Dyadic planning has been defined as formulating plans together with a partner which specify where, when, and how the target person will perform an intended behavior (Burkert et al., 2011). The partner’s role refers to supporting the target person in the planning process. By contrast, collaborative planning refers to two people jointly formulating joint plans to be enacted together (Prestwich et al., 2012). To the best of our knowledge, effects of individual, dyadic, and collaborative planning have not been directly compared, previously. Moreover, research has focused on romantic dyads (Burkert et al., 2012; Knoll et al., 2017) while joint planning of sitting and exercising together may involve other types of partners, including coworkers, family members, or friends. Among adults, hours of SB may be spent in company of coworkers (e.g., sitting at work) or close friends (e.g., leisure time activities such as playing computer games; De Cocker et al., 2016). Effects of dyadic or collaborative planning have been mainly evaluated using short-term follow-ups (i.e., ≤3 months; Knoll et al., 2017; Prestwich et al., 2012) and evidence for long-term effects is scarce (Keller et al., 2020). Previous studies have investigated dyadic or collaborative planning for PA (Knoll et al., 2017; Prestwich et al., 2012) but the effects of dyadic or collaborative planning on SB remain unclear. We found no previous studies of planning to reduce SB assessed using ‘objective’ measures (but see De Cocker et al., 2016 for a report of ‘objective’ assessment in a subsample).

Plans to reduce health-compromising behaviors may refer either to avoiding an undesirable habitual behavior or replacing (displacing) the undesirable behavior with an alternative health-enhancing behavior. A meta-analysis on individual planning and unhealthy eating habits has shown that planning to increase healthy eating was more effective than planning to diminish unhealthy eating patterns (Adriaanse et al., 2011). Instead of planning to avoid an undesirable habitual behavior (SB), planning to engage in alternative health-enhancing behaviors (i.e., PA), may be a more promising approach (Gardner and Rebar, 2019). Similarly, previous research testing effects of individual planning on SB used PA planning as the intervention strategy (Schroé et al., 2020).

This randomized controlled trial investigates if, compared to SB/PA education, three types of planning (individual, dyadic, and collaborative) reduce SB time (the primary outcome). In addition, the ratios of time spent on SB to (1) time spent on LIPA, and (2) time on LIPA combined with MVPA time, were evaluated at short-term (post-intervention, 1-week) and long-term (36-week) follow-ups. Target person–partner dyads were enrolled.

2. Methods

2.1. Participants

In total, N = 320 dyads (320 target persons and 320 partners) participated at baseline (Time 0). Fig. 1 presents participant flow across measurement points.

All dyads were in a close relationship, defined as a romantic, work-related, family relationship, or a close friendship, lasting for at least one year and involving at least several meetings every week. Further inclusion criteria for dyads were: (1) target persons and partners being at least 18 years old; (2) during the initial interview at least one person in the dyad (henceforth called as target person) declared PA levels that were below the recommended threshold (WHO, 2010, 2020), that is, 150 min of MVPA per week and/or were recommended by a specialist to reduce SB and increase their PA levels due to type-2 diabetes or cardiovascular diseases; (3) target persons were reporting at least moderate intention to initiate regular PA; (4) providing informed consent.

Individuals with chronic conditions were encouraged to obtain medical clearance for regular MVPA participation from their general practitioner/specialist consultant. When both dyad members did not meet recommended PA levels and/or were recommended by a specialist to reduce SB and increase their PA levels due to type-2 diabetes or cardiovascular diseases, participants were asked to self-assign the roles of target persons/partners.

‘Target persons’ were defined as individuals who met the inclusion

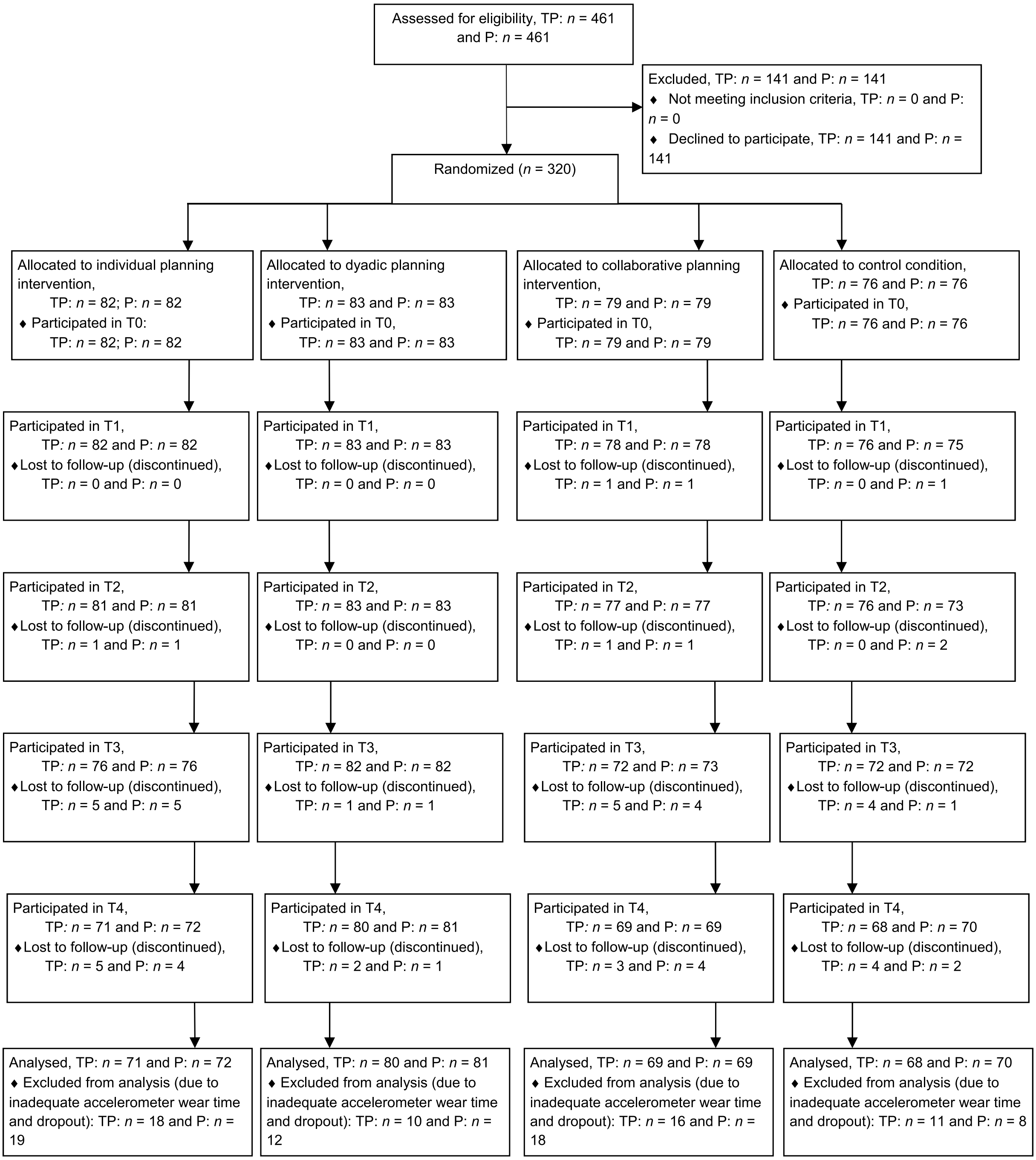

Fig. 1. The participant flow diagram. *Note:* TP = target persons; P = partners.

criteria and who declared that they did not adhere to PA guidelines (WHO, 2010, 2020) or were recommended to increase their PA and reduce SB due to type-2 diabetes or cardiovascular diseases. ‘Partners’ were the second dyad members, who were target persons’ romantic partners, coworkers, family members, or friends. In other words, the term ‘partner’ denotes the dyad member other than the target person, and it is not used to represent ‘partner’ as proposed in the actor-partner interdependence model (Kenny and Kashy, 2014).

The descriptive information about the study participants is presented in Table 1.

2.2. Procedures

This study reports results for the secondary outcome of a larger randomized controlled trial, registered at ClinicalTrials.gov (NCT03011385). The study was approved by Research Ethics Committee at the first author’s institution. The trial follows the Consolidated Standards of Reporting Trials (Supplemental File 1) and the Template for Intervention Description and Replication guidelines (Supplemental File 1).

Data were collected between December 2016 and February 2020 in 24 urban locations and 7 rural locations in south-western Poland. Participants were recruited via advertisements published in social media or at websites of non-governmental organizations; recruitment was also conducted in person (by experimenters) or via advertisements during health promotion events organized by the city council, at hospitals, specialist clinics, general practitioners’ offices, health-related non-governmental organizations, universities, and senior clubs, etc.

Table 1
Sample characteristics at baseline.

	Collaborative planning condition (n = 79)		Dyadic planning condition (n = 83)		Individual planning condition (n = 82)		Control condition (n = 76)		Total (N = 320 dyads)		Between-group differences F/χ^2 (p)	
	Target Persons	Partners	Target Persons	Partners	Target Persons	Partners	Target Persons	Partners	Target Persons	Partners	Target Persons	Partners
Mean Age (*SD*)	43.99 (17.56)	44.61 (17.57)	41.49 (16.34)	37.87 (14.60)	45.23 (17.66)	44.17 (17.17)	44.83 (16.53)	42.79 (16.16)	43.86 (17.02)	42.32 (16.55)	0.794 (.498)	**2.920 (.034)**
Gender (%)											1.589 (.662)	0.963 (.810)
Female	59.5	63.3	68.7	60.2	63.4	68.3	65.8	64.5	64.4	64.1		
Male	40.5	36.7	31.3	39.8	36.6	31.7	34.2	35.5	35.6	35.9		
BMI (%)											0.880 (.454)	2.491 (.060)
Overweight/obese	60.7	55.7	61.5	44.6	61.0	54.9	64.5	51.4	61.8	51.6		
Normal body weight	38.0	41.8	34.9	54.2	36.6	41.5	35.5	48.7	36.3	46.6		
Range: minimum/ maximum	17.51/ 48.22	17.82/ 40.51	16.94/ 46.51	17.45/ 34.89	17.51/ 58.57	16.95/ 53.24	19.90/ 41.21	18.99/ 38.06	16.94/ 58.57	16.95/ 53.24		
Mean (*SD*)	27.85 (6.11)	25.49 (4.11)	27.49 (6.14)	24.73 (3.53)	29.00 (7.98)	26.61 (5.95)	27.75 (5.01)	25.93 (4.32)	28.03 (6.42)	25.69 (4.60)		
Education (%)											1.021 (.383)	1.339 (.262)
Primary education	1.3	1.3	2.4	1.2	2.4	2.4	2.6	0.0	2.2	1.3		
High school	38.0	29.1	33.7	37.3	41.5	36.6	35.5	43.4	37.2	36.6		
Vocational/post-secondary	1.3	3.8	0.0	12.0	9.8	2.4	1.3	2.6	3.1	5.3		
University degree	59.5	65.8	63.8	49.4	46.4	58.6	60.5	53.9	57.5	56.8		
Economic Status (%)											0.929 (.427)	1.264 (.287)
Below average	7.6	5.1	2.4	2.4	8.5	11.0	3.9	9.2	5.6	6.9		
Average for family in Poland	49.4	45.6	51.8	51.8	52.4	46.3	55.3	53.9	52.2	49.4		
Above average	43.1	49.4	45.7	45.7	39.0	42.7	40.8	36.8	42.2	43.7		
Participants with chronic illnesses (%)											8.172 (.226)	3.734 (.713)
CVD/type-2 diabetes	40.0	15.9	29.1	13.2	47.4	20.0	41.4	17.7	39.4	16.7		
Other chronic illness	30.7	27.5	32.9	26.3	24.4	17.3	20.0	27.4	27.2	24.5		
Type of the relationship											5.828 (.120)	4.476 (.214)
Romantic relationship	70.9	69.6	57.8	60.2	53.7	53.7	64.5	63.2	61.6	61.6		
Other (e.g., friends, family members)	29.1	30.4	42.2	39.8	46.3	46.3	35.5	36.8	38.4	38.4		
Meeting physical activity guidelines by the WHO (%)											2.674 (.445)	3.469 (.325)
Yes	8.9	17.7	10.8	19.3	12.2	24.4	17.1	28.9	12.2	22.5		
No	91.1	82.3	89.2	80.7	87.8	75.6	82.9	71.1	87.8	77.5		

Note. BMI = Body mass index; *SD* = Standard deviation; CVD = Cardiovascular diseases; bold coefficients represent significant relationships. Meeting physical activity guidelines proposed by the WHO: no (0) = less than 75 min/week of vigorous physical activity or less than 150 min/week of moderate-to-vigorous physical activity, yes (1) = at least 75 min/week of vigorous physical activity or at least 150 min/week of moderate-to-vigorous physical activity.

Potential participants were informed about the study aims, inclusion criteria, and study procedures. After familiarizing themselves with the study information materials participants were asked to provide informed consent. Measurements and intervention/control group procedures took place at the first author's university or in other locations (e.g., at participants' homes, in non-governmental organizations, senior clubs) if such preferences were indicated by participants. Experimenters were psychologists, psychology master students, nurses, or teachers (n = 38), trained to collect data and deliver experimental procedures. There was no financial compensation for participation; participants received a thank-you gift (value 5–10 EUR) after each measurement.

After checking for the inclusion criteria and before the Time 0 (T0) measurement, dyads were randomly assigned to one of four conditions: individual planning (n = 82), dyadic planning (n = 83), collaborative planning (n = 79), or the educational control condition (n = 76). Participants, but not experimenters, were blinded to participants' assignment to experimental groups. Randomization was conducted using random digit generator (no stratification was applied). The researcher conducting randomization was blinded to the participant enrollment and the intervention assignment. The following behavior change techniques (BCTs) were used in the three planning conditions: action planning, barrier identification, coping planning, prompting self-talk, social support/social change (Abraham and Michie, 2018; Michie et al., 2011).

Across conditions, dyads participated in five face-to-face assessment meetings: Time 0 [T0], baseline; Time 1 [T1], 1 week after baseline; Time 2 [T2], 2 weeks after baseline; Time 3 [T3], 9 weeks after baseline; Time 4 [T4], 36 weeks after baseline. Additionally, four booster phone-calls were conducted (3 calls at 1–4 weeks after T2; 1 call at 1 week after T3). Fig. 2 presents the details of the study design.

All dyads participated in a face-to-face education and received brochures regarding nutrition (at T0, T3), SB, and PA (at T1, T2, T3). Dyads

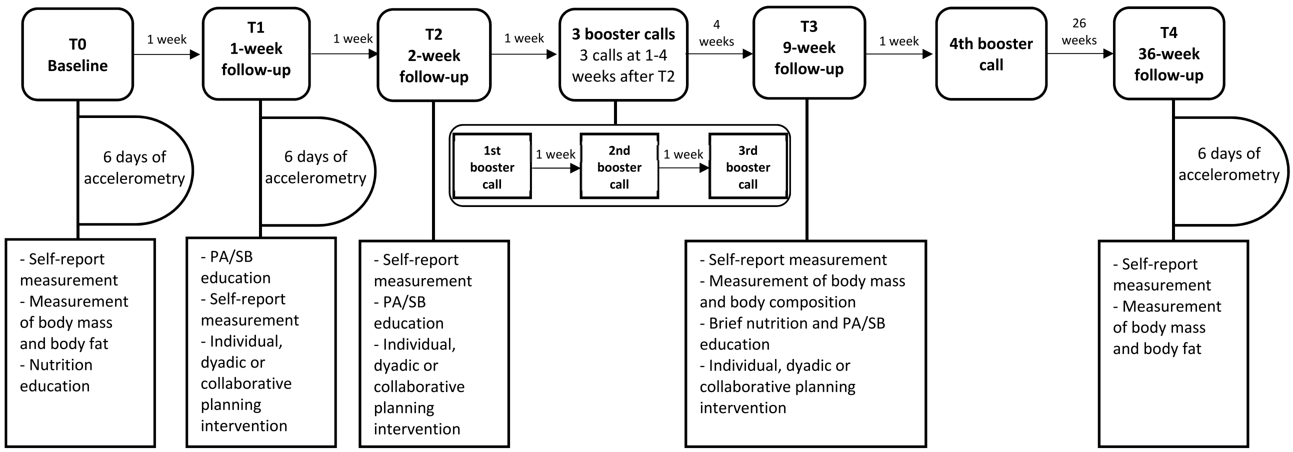

Fig. 2. The measurement and intervention points over time. N*ote:* Figure presents the study procedure which was conducted in target person-partner dyads (N = 320). In the current analyses we included three time points T0, T1, and T4. T = Time, PA = physical activity, SB = sedentary behavior.

assigned to the individual, dyadic, or collaborative planning conditions took part in respective planning interventions procedures, conducted face-to-face (at T1, T2, T3). Interventional materials (PA planning sheets) for each planning condition had a similar structure, but differed in their content. Phone-call booster sessions (3 after T2 and 1 after T3) aimed at reminding participants of the educational information across all conditions and repeating the planning procedures for participants from the three planning conditions. All participants wore accelerometers for 6 days following the T0, T1, and T4 assessments.

Before T0, potential participants completed self-reports to assess if they met the WHO guidelines regarding PA (see Supplemental File 1). Self-reported data were collected at T0, T1, T2, and T3. For example, demographic variables were collected at T0, intention to reduce SB was assessed at T1, self-reported plans were assessed at T2. Other self-report measures (not used in this study), applied across the assessment points, included social cognitive variables, such as PA self-efficacy, risk perception, and the use of social control strategies.

2.3. Experimental procedures

Across the experimental procedures, the term ‘target person’ denotes the member of the dyad who did not meet recommended PA levels and/or was recommended to reduce SB and increase PA due to type-2 diabetes or cardiovascular diseases. The term ‘partner’ refers to the second person in the dyad. In case both participants did not meet the respective recommendations, the dyads were asked to self-assign the roles of target persons/partners and follow the procedures of these assigned roles.

Control Condition. Nutrition, PA, and SB education were delivered to target persons and partners and included discussion of the respective WHO guidelines and a takeaway leaflet. Participants were introduced to the study website which included all information available in leaflets and key issues discussed during the face-to-face education (for details see Supplemental File 1). The educational component, leaflets, and the website were introduced in the same way to all participants across the study conditions. The 4 phone-call booster sessions repeated the education component.

Individual Planning Condition. After the education session at T1, dyads participated in an individual PA planning, including a formation of a detailed action plan and a detailed coping plan for the PA in the following week (7 days) (Knäuper et al., 2018; Luszczynska, 2006; Luszczynska et al., 2007). Participants were instructed by the experimenters on how to form action plans (action planning), asked to identify the barriers that may prevent them from acting as planned, and also instructed on how to form coping plans (coping planning, barrier identification). Next, participants completed their planning forms (action planning). The completed forms were discussed with the experimenter who encouraged participants to use self-talk and self-instruction to reflect on whether the plans could fit into their daily schedule (prompting self-talk). Participants were also supported and praised by the experimenter for their engagement in forming detailed plans (social support/social change) fitting their daily routines (for details see Supplemental File 1). Weekly planning sheets were used in the intervention, in line with previous research (Knäuper et al., 2018; Luszczynska, 2006).

Target persons and partners were asked to form PA plans for their own PA. The 4 phone-call booster sessions repeated individual planning and education.

Dyadic Planning Condition. The procedures were the same as those used in the individual planning condition except that PA plans were created by both dyad members together, with PA plans referring to PA of the target person only. Partners were instructed to support the target person in creating their PA plans. Procedures were adapted from previous research (Keller et al., 2020; Knoll et al., 2017; Radtke et al., 2018; Prestwich et al., 2014). The 4 phone-call booster sessions included dyadic planning and education.

Collaborative Planning Condition. Target persons and partners received the intervention using very similar procedures to those employed in individual and dyadic planning conditions. In this case, however, the dyads were asked to discuss preferred types of PA that they could do together and then to create a joint plan that they could execute together in the next week. Procedures were adapted from previous research (Prestwich et al., 2012, 2014). The 4 phone-call booster sessions repeated collaborative planning and education.

2.4. Materials

2.4.1. Main outcome, sedentary behavior time, and secondary outcomes (SB/LIPA proportion and SB/LIPA + MVPA proportion) at T0, T1, and T4

Three indices of SB were computed: (1) SB time was calculated as the average minutes of SB per hour of wear time; (2) SB/LIPA proportion (Spittaels et al., 2012), calculated as the average minutes of SB per hour of wear time divided by average LIPA time per hour of wear time; (3) SB/LIPA + MVPA proportion (Hamilton et al., 2008; Prestwich et al., 2014), calculated as average minutes of SB per hour of wear time divided by average total PA time (light, moderate, vigorous, and very vigorous) per hour of wear time. Thus, all SB indices accounted for within-person adjustment for individual wear time, as the total minutes of SB (obtained across the days included in a respective measurement point) were divided by the number of hours of wear time per participant.

The three indices were assessed using accelerometers ActiGraph GT3X-BT. This method shows reasonable sensitivity and accuracy in distinguishing different types of PA and SB (Skotte et al., 2014).

Participants were instructed to wear accelerometers above their right hip during their waking hours (at least 14 h a day) for 6 days.

Data from each participant were identified as 'valid wear time' and used in the analyses only if devices had been worn for at least 8 h per day, for a minimum of 3 days during the respective assessment period (Prescott et al., 2020). Data scoring methods were based on the Freedson VM3 (2011) (Sasaki et al., 2011) and the Freedson Adult (1998) (Freedson et al., 1998) algorithms with the Actilife software (Sasaki et al., 2011). The first day of the T0 measurement was excluded. Non-wear time was calculated using epoch-based algorithm based on Choi (Choi et al., 2011). To better capture SB as well as MVPA, 10-sec epochs were used (Quante et al., 2015).

2.4.2. *Intention to reduce sedentary behavior at T1*

SB intention was measured at T1 (i.e., one week after T0, before SB-related intervention at T1) using 2 items (Maher and Conroy, 2015), 'I intend to take active breaks from sitting at least once an hour over the next week' and 'I intend to sit for a maximum of 5 h (in total) a day over the next week'. Responses ranged from 1 (definitely not) to 4 (definitely yes). The two items were weakly but significantly correlated in target persons: $r = .21$, $p < .01$, $M = 3.11$, $SD = 0.68$ and marginally correlated in partners: $r = .11$, $p = .05$, $M = 3.11$, $SD = 0.68$.

2.4.3. *Self-reported own plans and collaborative plans (with a partner) at T2*

To conduct the manipulation check, self-reported own planning was assessed with 3 items (Schwarzer et al., 2008), for example, 'During the last week I have formed my own plans regarding when to exercise' with Cronbach's alpha of .98 for measures applied in target persons and in partners. Self-reported collaborative planning was assessed with 3 parallel items, for example, 'During the last week, I and my partner have formed joint plans regarding where to exercise together' with Cronbach's alpha of .98 for target persons and .97 for partners. Response scales and descriptive statistics are reported in Supplemental File 1.

2.4.4. *BMI at T0*

Body height was measured with standard medically-approved telescopic height measuring rods. Body weight and percent of body fat were assessed with certified bioimpedance floor scales with a measurement error <1% (Beurer, model BF-18 and BF-530).

2.4.5. *Sociodemographic variables at T0*

Sociodemographic covariates were: age; gender; education, measured as years of education; perceived economic status, measured by a question 'Compared to the economic situation of the average family in Poland, how would you rate the economic status of your family?' with answers ranging from 'much below the average' (1) to 'much above the average' (5); the type of relationship measured by a question 'How would you describe the type of your relationship with your dyad partner?' with following answers: romantic relationship, close family relationship, close friendship, work-related relationship, other (please specify). For responses on the latter item, a 'dyad in a romantic relationship' variable was coded with 1 = romantic relationship and 0 = other relationship.

2.5. *Analyses*

Sample sizes were determined with G*Power calculator to secure power of .80, assuming medium-size effects of planning on the primary outcome, SB time. Assuming effect size of $\varsigma^2 = 0.25$, power of .80, $p = .05$, and four experimental conditions the total sample should include 279 dyads. Analyses were performed in IBM SPSS 26. Missing data were accounted for with full information maximum likelihood method (Cham et al., 2017). Although data for target persons' sociodemographic variables, SB intention, the type of relationship (romantic vs other), SB time, SB/LIPA proportion and SB/LIPA + MVPA proportion was missing completely at random, Little's MCAR$\chi^2 = 168.517$ ($df = 145$), $p = .088$, respective data for partners were not missing at random, Little's MCAR$\chi^2 = 204.143$ ($df = 157$), $p = .007$. Linear mixed models (Bolger and Laurenceau, 2013) were used to model effects of the three planning interventions on SB indicators. To model effects over time, a linear time variable (number of weeks since T0) was created and coded as '0' for baseline (T0), '1' for 1-week follow-up (T1) and '36' for 36-week follow-up (T4).

All of the models including long-term changes (T0-T4) were analyzed with intercept and linear time variable estimated as random effects predictors. Models including short-term changes (T0-T1) did not converge upon inclusion of the linear time variable, therefore, in this case, only intercept was modelled as a random effects predictor (Barr et al., 2013). The true R^2 (the squared correlation between the actual outcome and the outcome predicted by fixed effects; Hoffman, 2015) was computed to estimate the size of total effects.

The linear mixed-models were calculated to test SB changes measured from T0 to T1 as well as from T0 to T4, with the control condition as a reference group, the three planning conditions as respective dummy-coded predictors, and time × planning conditions interactions as predictors. The models were calculated for target persons and partners separately.

To assess the robustness of the findings, three sensitivity analyses were conducted (see Supplemental File 1). The first sensitivity analysis controlled for gender (dummy coded, 1 = male, 0 = female) and grand-mean centered age and BMI. The second sensitivity analysis included additional covariates: grand-mean centered intention to reduce SB (T1), years of schooling, the type of relationship (romantic relationship = 1 vs other relationships = 0), and perceived economic status. The third sensitivity analysis accounted for covariates included in the second sensitivity analysis and, additionally, for meeting the WHO recommendations for physical activity (WHO, 2020) (meeting the guidelines = 1, not meeting the guidelines = 0), assessed in target persons and partners.

To explore whether the effects of collaborative planning differed from effects observed in other conditions, additional analyses with the collaborative planning condition as a reference group were conducted (Supplemental File 1).

3. Results

3.1. *Preliminary analysis*

3.1.1. *Descriptive statistics for sedentary behavior*

Descriptive statistics for the main outcome, SB time, and secondary outcomes, SB/LIPA proportion and SB/LIPA + MVPA proportion, are displayed in Table 2.

3.1.2. *Attrition analyses*

The dropout rates are presented in Fig. 1. Dyads who dropped out before T4 did not differ from continuing dyads across the outcome variables and covariates (see Supplemental File 1), except for BMI. Participants who dropped out had a higher BMI (target persons: $M = 30.17$, $SD = 7.49$; partners: $M = 27.53$, $SD = 6.07$) compared to completers (target persons: $M = 27.76$, $SD = 6.23$, F [1, 319] = 4.44, $p = .036$, $\eta^2 = 0.01$; partners: $M = 25.50$, $SD = 4.38$, F [1, 319] = 5.49, $p = .020$, $\eta^2 = 0.03$).

3.1.3. *Randomization check*

Details of the randomization check are presented in Supplemental File 1. Among target persons, the three planning groups significantly differed from the control group at T0 regarding SB/LIPA proportion, F (3,299) = 2.98, $p = .032$, $\eta^2 = 0.03$ and SB/LIPA + MVPA proportion, F (3,299) = 2.95, $p = .033$, $\eta^2 = 0.03$. Among partners, there were no significant between-condition differences for SB indicators at T0. There were no significant baseline between-condition differences across the

Table 2
Descriptive statistics and internal consistency for study variables.

Sedentary behavior index		Individual planning condition (n = 79)		Dyadic planning condition (n = 83)		Collaborative planning condition (n = 82)		Control group condition (n = 76)	
		Target person *M* (*SD*)	Partner *M* (*SD*)	Target person *M* (*SD*)	Partner *M* (*SD*)	Target person *M* (*SD*)	Partner *M* (*SD*)	Target person *M* (*SD*)	Partner *M* (*SD*)
Sedentary behavior time (average min per hour of wear-time)	T0	36.46 (5.27)	34.52 (6.57)	36.81 (6.19)	35.36 (5.68)	36.34 (5.23)	36.14 (5.29)	34.45 (5.50)	34.31 (7.31)
	T1	36.22 (5.82)	33.71 (6.05)	36.94 (6.06)	35.14 (5.24)	35.57 (5.13)	35.68 (5.14)	35.53 (5.60)	34.05 (6.86)
	T4	35.46 (5.96)	34.40 (6.50)	36.02 (6.86)	34.83 (5.58)	35.55 (5.27)	36.40 (5.50)	34.57 (5.22)	34.19 (6.62)
	ICC	0.74	0.89	0.86	0.84	0.84	0.85	0.85	0.92
Proportion of time spent in sedentary behavior and light intensity physical activity (per hour of wear time)	T0	2.16 (0.81)	2.03 (1.06)	2.27 (0.93)	2.13 (0.91)	2.13 (0.74)	2.16 (0.90)	1.88 (0.77)	2.02 (1.02)
	T1	2.17 (0.85)	1.87 (0.84)	2.31 (0.94)	2.06 (0.82)	2.02 (0.74)	2.06 (0.79)	2.05 (0.83)	1.95 (0.93)
	T4	1.99 (0.84)	2.00 (1.04)	2.22 (0.97)	2.01 (0.80)	2.02 (0.74)	2.17 (0.86)	1.90 (0.81)	1.92 (0.88)
	ICC	0.75	0.88	0.83	0.82	0.83	0.88	0.84	0.89
Proportion of the time spent in sedentary behavior and total physical activity (per hour of wear time)	T0	1.69 (0.65)	1.43 (0.55)	1.77 (0.73)	1.52 (0.52)	1.66 (0.58)	1.57 (0.50)	1.46 (0.60)	1.45 (0.59)
	T1	1.67 (0.65)	1.41 (0.62)	1.77 (0.70)	1.54 (0.56)	1.57 (0.55)	1.59 (0.64)	1.59 (0.64)	1.48 (0.66)
	T4	1.59 (0.70)	1.52 (0.74)	1.70 (0.75)	1.49 (0.57)	1.57 (0.62)	1.68 (0.65)	1.47 (0.58)	1.48 (0.63)
	ICC	0.71	0.87	0.85	0.83	0.84	0.86	0.84	0.90

Note. T0 = baseline accelerometry, a week prior to the experimental procedures; T1 = the follow-up accelerometry, the week directly after T0 accelerometry assessment; T4 = the follow-up accelerometry, 36 weeks after T0 accelerometry assessment; *M* = Mean; *SD* = Standard deviation; *ICC* = Intra-class correlation coefficient (within-person); total physical activity = time spent in light-, moderate-, and vigorous - intensity physical activity. For sample sizes at each measurement point see Fig. 1.

majority of sociodemographic variables (Table 1).

3.1.4. *Manipulation check (for details see Supplemental File 1)*

At T2 (one week after the first planning session), target persons assigned to the three planning conditions tended (p = .063) to report that they have formed plans more often than those in the control condition, whereas partners assigned to individual or collaborative conditions reported forming own plans more often (p = .017) than those assigned to the control or dyadic conditions. Furthermore, target persons and partners taking part at the collaborative condition reported forming collaborative plans more often at T2 ($p < .001$), compared to individuals assigned to any other conditions. Concluding, target persons and partners differed in self-reported own and collaborative planning.

3.1.5. *Observed harms*

No unintended effects or harms due to study participation were observed.

3.2. *Effects of individual, dyadic, and collaborative PA planning on SB indicators*

3.2.1. *Effects of individual, dyadic, and collaborative PA planning on SB time*

Target Persons. Two-level models predicting SB time (average minutes per hour of wear time) between T0 (baseline) and post-intervention (T1) showed that SB in the control condition on average started at 34.50 min/h at T0 and increased by 1.02 min/h at T1 (see Table 3, upper panel). A significant time × collaborative planning condition interaction (Estimate = −1.73; *SE* = 0.69; p = .013; see Table 3, upper panel) was found, indicating that target persons in the collaborative planning condition reduced their SB from T0 to T1 (a decrease from 36.34 at T0 to 35.57 at T1; see Table 2) compared to the control condition (an increase from 34.45 at T0 to 35.53 at T1; see Table 2). The sensitivity analyses, controlling for three sets of covariates (age, gender, and BMI; additional covariates in the second analysis: education, intention, the type of relationship, and perceived economic status; additional covariates in the third analysis: meeting PA guidelines by the target person and the partner) yielded similar findings (see Supplementary Tables 1, 2, 3 in Supplemental File 1). When contrasting target persons from the collaborative planning condition with those from the 3 remaining conditions at T1, it was found that the time × condition interaction effect was significant for the comparison made between collaborative planning and control conditions, but not for individual or dyadic planning conditions (see Supplementary Table 4, Supplemental File 1).

Among the two-level models predicting changes in SB time between T0 and T4, there were no significant effects of the time × condition interactions (see Table 3, bottom panel).

Partners. Changes in partners' SB time were not predicted by time × condition interactions between T0 and T1 or between T0 and T4 (see Table 3).

3.2.2. *Effects of three types of PA planning on proportion of SB time and LIPA time*

Target Persons. A significant effect of time × condition interaction for collaborative planning (Estimate = −0.26; *SE* = 0.11; p = .019; see Table 3, upper panel) was found, indicating that between T0 and T1 target persons in the collaborative planning condition displaced time spent on SB by time spent on LIPA (a decrease in SB/LIPA proportion from 2.13 to 2.02; see Table 2), which significantly differed from the change in the control condition (an increase from 1.88 at T0 to 2.05 at T1; see Table 2). The sensitivity analyses, controlling for two sets of covariates (age, gender, and BMI; additional covariates in the second analysis: education, intention, the type of relationship, and perceived economic status) yielded similar significant findings (see Supplementary Tables 1 and 2 in Supplemental File 1). The third sensitivity analysis, accounting for two additional covariates, meeting PA guidelines by the target person and the partner, showed a statistical trend (p = .052) for time × condition interaction for collaborative planning (see Supplementary Table 3 in Supplemental File 1). When contrasting target persons from the collaborative planning condition with those from the 3 remaining conditions at T1, it was found that the time × condition

Table 3
Effects of collaborative, dyadic and individual planning intervention on sedentary behavior indicators.

	Target person									Partner								
	Sedentary behavior time (average min per hour of wear-time)			Proportion of time spent in sedentary behavior and light intensity physical activity			Proportion of time spent in sedentary behavior and total physical activity			Sedentary behavior time (average min per hour of wear-time)			Proportion of time spent in sedentary behavior and light intensity physical activity			Proportion of time spent in sedentary behavior and total physical activity		
	Est *(SE)*	*p*	CI_{95} Lower Upper	Est *(SE)*	*p*	CI_{95} Lower Upper	Est *(SE)*	*p*	CI_{95} Lower Upper	Est *(SE)*	*P*	CI_{95} Lower Upper	Est *(SE)*	*p*	CI_{95} Lower Upper	Est *(SE)*	*p*	CI_{95} Lower Upper
Changes between T0 and T1 (after the first intervention session)																		
Intercept	34.50 (0.67)	<.001	33.19 35.81	1.89 (0.10)	<.001	1.70 2.08	1.47 (0.08)	<.001	1.32 1.62	34.05 (0.71)	<.001	32.65 35.45	1.99 (0.11)	<.001	1.78 2.20	1.43 (0.07)	<.001	1.30 1.57
Time	**1.02** **(0.50)**	**.041**	**0.04** **2.00**	**0.16** **(0.08)**	**.047**	**0.00** **0.31**	*0.11* *(0.06)*	*.061*	*−0.01* *0.23*	−0.08 (0.44)	.864	−0.94 0.79	−0.05 (0.07)	.460	−0.20 0.09	0.04 (0.05)	.447	−0.06 0.13
Collaborative planning	**1.81** **(0.93)**	**.051**	**0.01** **3.63**	*0.24* *(0.14)*	*.083*	*−0.03* *0.51*	*0.18* *(0.11)*	*.087*	*−0.03* *0.39*	**2.13** **(0.99)**	**.033**	**0.18** **4.09**	0.18 (0.15)	.230	−0.11 0.48	0.14 (0.10)	.154	−0.05 0.33
Dyadic planning	**2.41** **(0.92)**	**.009**	**0.61** **4.21**	0.39 (0.14)	**.004**	**0.12** **0.66**	**0.31** **(0.10)**	**.004**	**0.10** **0.51**	1.31 (0.98)	.184	−0.63 3.25	0.14 (0.15)	.340	−0.15 0.43	0.09 (0.09)	.351	−0.10 0.27
Individual planning	**1.95** **(0.93)**	**.036**	**0.13** **3.78**	0.28 (0.14)	**.045**	**0.01** **0.55**	**0.21** **(0.11)**	**.048**	**0.00** **0.42**	0.56 (1.00)	.573	−1.40 2.52	0.06 (0.15)	.709	−0.24 0.35	0.01 (0.10)	.914	−0.18 0.20
Time × Collaborative planning	**−1.73** **(0.69)**	**.013**	**−3.09** **−0.37**	−0.26 (0.11)	**.019**	**−0.47** **−0.04**	**−0.20** **(0.08)**	**.018**	**−0.36** **−0.03**	−0.35 (0.61)	.564	−1.55 0.85	−0.03 (0.10)	.755	−0.23 0.17	−0.01 (0.07)	.918	−0.14 0.12
Time × Dyadic planning	*−1.21* *(0.69)*	*.080*	*−2.56* *−0.14*	−0.16 (0.11)	.150	−0.37 0.06	*−0.15* *(0.08)*	*.082*	*−0.31* *0.02*	−0.37 (0.61)	.544	−1.56 0.83	−0.05 (0.10)	.642	−0.25 0.15	−0.04 (0.07)	.506	−0.17 0.09
Time × Individual planning	*−1.26* *(0.69)*	*.070*	*−2.62* *−0.10*	−0.16 (0.11)	.146	−0.37 0.06	−0.13 (0.08)	.123	−0.29 0.04	−0.68 (0.61)	.270	−1.88 0.53	−0.09 (0.10)	.408	−0.29 0.12	−0.05 (0.07)	.417	−0.19 0.08
Changes between T0 and T4 (the 36-week follow-up)																		
Intercept	35.06 (0.62)	<.001	33.84 36.28	1.98 (0.09)	<.001	1.80 2.16	1.54 (0.07)	<.001	1.40 1.68	34.02 (0.68)	<.001	32.69 35.36	1.97 (0.10)	<.001	1.77 2.17	1.45 (0.06)	<.001	1.33 1.58
Time	0.00 (0.02)	.928	−0.04 0.03	0.00 (<0.001)	.701	−0.01 0.00	0.00 (<0.001)	.735	0.00 0.00	0.01 (0.02)	.368	−0.02 0.05	0.00 (<0.001)	.926	0.00 0.00	0.00 (<0.001)	.362	0.00 0.00
Collaborative planning	0.92 (0.86)	.289	−0.78 2.61	0.10 (0.13)	.442	−0.15 0.35	0.08 (0.10)	.428	−0.11 0.27	**1.95** **(0.95)**	**.041**	**0.08** **3.82**	0.16 (0.14)	.262	−0.12 0.44	0.13 (0.09)	.154	−0.05 0.31
Dyadic planning	**1.76** **(0.85)**	**.040**	**0.08** **3.44**	**0.30** **(0.13)**	**.019**	**0.05** **0.54**	**0.23** **(0.10)**	**.020**	**0.04** **0.42**	1.15 (0.94)	.221	−0.70 3.00	0.12 (0.14)	.404	−0.16 0.39	0.06 (0.09)	.473	−0.11 0.24
Individual planning	1.32 (0.86)	.125	−0.37 3.02	0.19 (0.13)	.130	−0.06 0.44	0.14 (0.10)	.143	−0.05 0.34	0.22 (0.95)	.817	−1.64 2.08	−0.01 (0.14)	.954	−0.27 0.29	−0.02 (0.09)	.828	−0.20 0.16
Time × Collaborative planning	−0.01 (0.02)	.745	−0.06 0.04	0.00 (<0.001)	.947	−0.01 0.01	0.00 (<0.001)	.981	−0.01 0.01	0.00 (0.02)	.995	−0.04 0.05	0.00 (<0.001)	.608	−0.01 0.01	0.00 (<0.001)	.566	0.00 0.01
Time × Dyadic planning	−0.02 (0.02)	.424	−0.07 0.03	0.00 (<0.001)	.923	−0.01 0.01	0.00 (<0.001)	.784	−0.01 0.00	−0.03 (0.02)	.195	−0.07 0.01	0.00 (<0.001)	.559	−0.01 0.00	0.00 (<0.001)	.288	−0.01 0.00
Time × Individual planning	−0.02 (0.02)	.354	−0.07 0.03	0.00 (<0.001)	.290	−0.01 0.00	0.00 (<0.001)	.500	−0.01 0.00	−0.02 (0.02)	.312	−0.07 0.02	0.00 (<0.001)	.772	−0.01 0.01	0.00 (<0.001)	.808	−0.01 0.00

Note. All of the models including long-term changes (T0-T4): intercept and linear time variable estimated as random effects predictors. Models including short-term changes (T0-T1): only intercept was modelled as a random effects predictor.
Intercept = baseline accelerometer assessment in control condition; Time = change over time weeks in reference group; Est = estimate; Cl_{95} = 95% confidence interval; total physical activity = time spent on light, moderate, vigorous physical activity; bold numbers indicate significant values ($p < .05$). Coefficients in italics represent statistical trends ($p < .10$). The control condition was the reference group in all analyses. For sample sizes at each measurement point see Fig. 1. Effect sizes: For the equation with: sedentary behavior time (T0-T1) truer $R^2 = 0.02$; sedentary behavior time (T0-T4) true $R^2 = 0.01$; proportion of time spent in sedentary behavior and light intensity physical activity (T0-T1) True $R^2 = 0.02$; proportion of time spent in sedentary behavior and light intensity physical activity (T0-T4) true $R^2 = 0.02$; proportion of the time spent in sedentary behavior and total physical activity (T0-T1) true $R^2 = 0.02$; proportion of the time spent in sedentary behavior and total physical activity (T0-T4) true $R^2 = 0.02$.

interaction effect was significant for the comparison made between collaborative planning and control conditions, but not for individual or dyadic planning conditions (see Supplementary Table 4 in Supplemental File 1).

The findings for the two-level models testing the effects of planning on SB/LIPA proportion across the 36 weeks (T0-T4) showed no significant time × condition interactions (see Table 3, bottom panel).

Partners. Regarding the findings for partners, SB/LIPA proportion was not predicted by time × condition interactions, neither when short term effects (T0-T1) were tested, nor when the long-term effects (T0-T4) were considered (see Table 3).

3.3. Effects of three types of PA planning on the proportion of SB time and LIPA + MVPA time

Target Persons. A significant effect of the time × condition interaction for collaborative planning (Estimate = −0.20; *SE* = 0.08; *p* = .018; see Table 3, upper panel) was found, indicating that between T0 and T1 target persons in the collaborative planning condition displaced time spent on SB by time spent on LIPA or MVPA: SB/LIPA + MVPA proportion values decreased from 1.66 to 1.57 (see Table 2), which significantly differed from the change in the control condition (an increase from 1.46 at T0 to 1.59 at T1; see Table 2). Similar significant patterns of associations were obtained in sensitivity analyses, controlling for two sets of covariates (age, gender, and BMI; additional covariates in the second analysis: education, intention, the type of relationship, and perceived economic status; see Supplementary Tables 1 and 2 in Supplemental File 1). The third sensitivity analysis, accounting for two additional covariates, meeting PA guidelines by the target person and the partner, showed a statistical trend (*p* = .053) for time × condition interaction for collaborative planning (see Supplementary Table 3 in Supplemental File 1). When contrasting target persons from the collaborative planning condition with those from the 3 remaining conditions at T1, it was found that the time × condition interaction effect was significant for the comparison made between collaborative planning and control conditions, but not for individual or dyadic planning conditions (see Supplementary Table 4 in Supplemental File 1).

Next, the effects of three types of planning interventions on target persons' SB/LIPA + MVPA proportion across the 36-weeks (T0-T4) were tested with linear mixed-models. No significant of time × condition interactions were found (see Table 3, bottom panel).

Partners. The changes in partners' SB/LIPA + MVPA proportion were not predicted by time × condition interactions, neither for T0-T1 period (see Table 3, upper panel) nor T0-T4 period (see Table 3, bottom panel).

4. Discussion

This study is among the first to evaluate the effects of different kinds of planning on short- and long-term changes in accelerometer-assessed sedentary behavior. We extended existing evidence by testing effects of individual, collaborative, and dyadic planning in dyads that were composed of target persons who did not meet PA guidelines and partners, including romantic partners, coworkers, family members or friend. Across all analyses conducted for three indices of SB and then repeated for various covariates, a consistent pattern of associations emerged: effects were observed only among target persons making collaborative plans, not individual or dyadic plans, and observed only at a short-term follow-up only.

The findings correspond to previous research showing no effects of individual PA planning on short-term changes in objectively measured SB (De Cocker et al., 2016) or self-reported SB (unless planning was combined with other self-regulatory strategies, e.g., self-monitoring; Schroé et al., 2020). Previous experimental research on effects of dyadic planning yielded no significant effects on target persons' and partners' PA (Keller et al., 2020; Knoll et al., 2017) which, again, corresponded to our findings, indicating no influence of dyadic planning on SB indicators, including SB/PA proportion.

Collaborative planning generated beneficial short-term changes in SB time and shifts towards a healthier balance between SB time and PA time. Earlier research had shown that collaborative planning influences self-reported PA levels (Prestwich et al., 2012), but, until now, there was no evidence for its effects on SB. Collaborative planning involves a social exchange in a dyad, including a joint discussion about plans and forming joint plans for joint future actions. The collaboration in dyads during the plan formation may trigger various social co-regulation processes, such as modelling, social support provision and receipt (Lüscher et al., 2019; Bolger and Laurenceau, 2013). Moreover, such collaborative planning involves a strong and accountable commitment to someone who is important in one's social network. Joint engagement in PA has also been shown to be an important predictor of individual physical activity (Berli et al., 2018). Future research could disentangle the complex social exchange and co-regulation processes which, together may make collaborative planning a more effective action-regulation strategy.

In contrast to collaborative planning, dyadic planning did not affect SB outcomes. Dyadic planning may also trigger social co-regulation processes (Burkert et al., 2011, 2012; Keller et al., 2020; Knoll et al., 2017) but it remains individual in that the plan represents future actions of just one person (i.e., the target person) rather than the joint action of a dyad. Dyadic planning has been developed in a context of post-surgery adaptation, where roles of target persons (i.e., patients) and partners were clear-cut and behavior change was recommended for patients only (Burkert et al., 2011, 2012). Further exploration of the role of the dyadic planning partner (e.g., expert versus intimate confidante) could identify what kind of planning support is most effective.

The findings indicated significant effects of collaborative planning for the target persons only. The inclusion criteria for being a target person in the present study included not meeting PA guidelines (WHO, 2010, 2020). This criterion may serve as a proxy indicator of less favorable balance between SB and PA time before entering the study. Target persons, who defined themselves as living an unbalanced life in terms of SB/PA, may have had stronger motivation to initiate a behavior change in terms of SB reduction.

It is noteworthy that no long-term effects were observed. All three planning interventions involved several repetitions of planning (face-to-face and by phone), therefore a lack of long term-effects cannot be explained merely by the limitations of the format/delivery of the intervention. The majority of planning research shows short-term effects and evidence for effects lasting >6 months is limited (Hagger et al., 2016). In addition, several theoretical models indicate that SB is influenced by physical environmental cues such that interventions involving changes in the physical environment (e.g., standing desks or standing meeting rooms) may assist with maintenance of reduced SB (Sallis and Owen, 2015).

4.1. Limitations

The study has limitations. Triaxial hip-worn accelerometers were used to capture both SB and PA aspects, whereas more preferable devices would involve ActivePal or comparable instruments allowing for a better differentiation between sitting and standing or SB and LIPA (Dempsey et al., 2020). The design accounted for a very short (1-week) and longer (36-week) follow-ups. Adding mid-term follow-ups (e.g., at 4 weeks) would allow to clarify change patterns over time after initial changes. The analyses were sufficiently powered to detect medium size effects, however, it is unlikely that very small changes could be detected. The planning referred to engaging in different forms of PA, whereas alternative approaches could focus on shortening sitting bouts or replacing sitting with standing. The randomization was not successful in terms of SB time, but all analyses were conducted controlling for the respective T0 index of SB. Although the overall dropout was low and not systematic across the majority of the study variables, participants who dropped out had higher BMI levels than those who completed the study. Therefore, BMI was controlled in sensitivity analyses. Future research should test if planning interventions are equally feasible and acceptable among people with normal and higher BMI levels, and carefully investigate the causes of dropout among participants with overweight/obesity.

5. Conclusion

This randomized controlled trial testing short-term and long-term effects of individual, dyadic, and collaborative planning showed short-term effects of collaborative planning on SB behavior of target persons, who were not meeting WHO PA guidelines (or were recommended to change their PA due to diabetes/cardiovascular diseases) prior to the study. The effects were consistent, observed across accelerometer-measured SB time, SB/LIPA proportion, and SB/LIPA + MVPA proportion. The successful initiation of behavior change (SB reduction) was not maintained at 36-week follow-up. Collaborative PA planning may be a valuable component of interventions, targeting SB change. Mechanisms underpinning the initial SB change and those behind sustainable SB reduction require further research.

Credit author statement

Zofia Szczuka: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. **Ewa Kulis:** Data curation, Investigation, Project administration, Resources, Visualization, Writing – review & editing. **Monika Boberska:** Data curation, Investigation, Project administration, Resources, Writing – review & editing. **Anna Banik:** Data curation, Investigation, Project administration, Resources, Writing – review & editing. **Magdalena Kruk:** Data curation, Investigation, Project administration, Resources, Writing – review & editing. **Jan Keller:** Formal analysis, Software, Writing – review & editing. **Nina Knoll:** Conceptualization, Formal analysis, Methodology, Software, Writing – review & editing. **Urte Scholz:** Conceptualization, Methodology, Writing – review & editing. **Charles Abraham:** Conceptualization, Writing – review & editing. **Aleksandra Luszczynska:** Conceptualization, Funding acquisition, Methodology, Software, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.114336.

References

Abraham, C., Michie, S., 2018. A taxonomy of behavior change techniques used in interventions. Health Psychol. 27 (3), 379–387. https://doi.org/10.1037/0278-6133.27.3.379.

Adriaanse, M.A., Vinkers, C.D.W., De Ridder, D.T.D., Hox, J.J., De Wit, J.B.F., 2011. Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. Appetite 56, 183–193. https://doi.org/10.1016/j.appet.2010.10.012.

Barr, D.J., Levy, R., Scheepers, C., Tily, H.J., 2013. Random effects structure for confirmatory hypothesis testing: keep it maximal. J. Mem. Lang. 68, 255–278. https://doi.org/10.1016/j.jml.2012.11.001.

Bélanger-Gravel, A., Godin, G., Amireault, S., 2013. A meta-analytic review of the effect of implementation intentions on physical activity. Health Psychol. Rev. 7, 23–54. https://doi.org/10.1080/17437199.2011.560095.

Berli, C., Bolger, N., Shrout, P.E., Stadler, G., Scholz, U., 2018. Interpersonal processes of couples' daily support for goal pursuit: the example of physical activity. Pers. Soc. Psychol. Bull. 44, 332–344. https://doi.org/10.1177/0146167217739264.

Boberska, M., Szczuka, Z., Kruk, M., Knoll, N., Keller, J., Hohl, D.H., Luszczynska, A., 2018. Sedentary behaviours and health-related quality of life. A systematic review and meta-analysis. Health Psychol. Rev. 12, 195–210. https://doi.org/10.1080/17437199.2017.1396191.

Bolger, N., Laurenceau, J.P., 2013. Intensive Longitudinal Methods: an Introduction to Diary and Experience Sampling Research. Guilford Press, New York.

Burkert, S., Knoll, N., Luszczynska, A., Gralla, O., 2012. The interplay of dyadic and individual planning of pelvic-floor exercise in prostate-cancer patients following radical prostatectomy. J. Behav. Med. 35, 305–317. https://doi.org/10.1007/s10865-012-9416-2.

Burkert, S., Scholz, U., Gralla, O., Roigas, J., Knoll, N., 2011. Dyadic planning of health-behavior change after prostatectomy: a randomized-controlled planning intervention. Soc. Sci. Med. 73, 783–792. https://doi.org/10.1016/j.socscimed.2011.06.016.

Carraro, N., Gaudreau, P., 2013. Spontaneous and experimentally induced action planning and coping planning for physical activity: a meta-analysis. Psychol. Sport Exerc. 14, 228–248. https://doi.org/10.1016/j.psychsport.2012.10.004.

Cham, H., Reshetnyak, E., Rosenfeld, B., Breitbart, W., 2017. Full information maximum likelihood estimation for latent variable interactions with incomplete indicators. Multivariate Behav. Res. 52, 12–30. https://doi.org/10.1080/00273171.2016.1245600.

Choi, L., Zhouwen, L., Matthews, C.E., Buchowski, M.S., 2011. Validation of accelerometer wear and nonwear time classification algorithm. Med. Sci. Sports Exerc. 43, 357–364. https://doi.org/10.1249/MSS.0b013e3181ed61a3.

De Cocker, K., De Bourdeaudhuij, I., Cardon, G., Vandelanotte, C., De Cocker, P.K., 2016. The effectiveness of a web-based computer-tailored intervention on workplace sitting: a randomized controlled trial. J. Med. Internet Res. 18, e96–e109. https://doi.org/10.2196/jmir.5266.

De Rezende, L.F.M., Sá, T.H., Mielke, G.I., Viscondi, J.Y.K., Rey-López, J.P., Garcia, L.M. T., 2016. All-cause mortality attributable to sitting time: analysis of 54 countries worldwide. Am. J. Prev. Med. 51 (2), 253–263. https://doi.org/10.1016/j.amepre.2016.01.022.

De Rezende, L.F.M., Rodrigues Lopes, M., Rey-López, J.P., Matsudo, V.K.R., Luiz, O.d.C., 2014. Sedentary behavior and health outcomes: an overview of systematic reviews. PloS One 9, 1–7. https://doi.org/10.1371/journal.pone.0105620.

Dempsey, P.C., Biddle, S.J.H., Buman, M.P., Chastin, S., Ekelund, U., Friedenreich, C.M., Katzmarczuk, P.t., Leitzmann, M.F., Stamatakis, E., van der Ploeg, H.P., Willumsen, J., Bull, F., 2020. New global guidelines on sedentary behaviour and health for adults: broadening the behavioural targets. Int. J. Behav. Nutr. Phys. Activ. 17 https://doi.org/10.1186/s12966-020-01044-0.

Ekblom-Bak, E., Ekblom, Ö., Bergström, G., Börjesson, M., 2016. Isotemporal substitution of sedentary time by physical activity of different intensities and bout lengths, and its associations with metabolic risk. Eur. J. Prev. Cardiol. 23, 967–974. https://doi.org/10.1177/2047487315619734.

Freedson, P.S., Melanson, E., Sirard, J., 1998. Calibration of the computer science and applications, inc. accelerometer. Med. Sci. Sports Exerc. 30, 777–781. https://doi.org/10.1097/00005768-199805000-00021.

Gardner, B., Rebar, A.L., 2019. Habit formation and behavior change. In: Oxford Research Encyclopedias: Psychology. Oxford University Press, Oxford. https://doi.org/10.1093/acrefore/9780190236557.013.129.

Gollwitzer, P.M., Crosby, C., 2018. Planning out future action, affect, and cognition. In: Oettingen, G., Sevincer, A.T., Gollwitzer, P. (Eds.), The Psychology of Thinking about the Future. The Guilford Press, New York, pp. 335–361.

Hagger, M.S., Luszczynska, A., de Wit, J., Benyamini, Y., Burkert, S., Chamberland, P.-E., Chater, A., Dombrowski, S.U., van Dongen, A., French, D.P., Gauchet, A., Hankonen, N., Karekla, M., Kinney, A.Y., Kwasnicka, D., Hing Lo, S., López-Roig, S., Meslot, C., Marques, M.M., Neter, E., 2016. Implementation intention and planning interventions in health psychology: recommendations from the Synergy Expert Group for research and practice. Psychol. Health 31, 814–839. https://doi.org/10.1080/08870446.2016.1146719.

Hamilton, M.T., Healy, G.N., Dunstan, D.W., Zderic, T.W., Owen, N., 2008. Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. Curr. Cardiovasc. Risk Rep. 2, 292–298. https://doi.org/10.1007/s12170-008-0054-8.

Hoffman, L., 2015. Longitudinal Analysis. Modeling Within-Person Fluctuation and Change. Routledge, New York.

Keller, J., Hohl, D.H., Hosoya, G., Heuse, S., Scholz, U., Luszczynska, A., et al., 2020. Long-term effects of a dyadic planning intervention with couples motivated to increase physical activity. Psychol. Sport Exerc. 49, e101710 https://doi.org/10.1016/j.psychsport.2020.101710.

Kenny, D.A., Kashy, D.A., 2014. The design and analysis of data from dyads and groups. In: Reis, H.T., Judd, C.M. (Eds.), Handbook of Research Methods in Social and Personality Psychology, second ed. Cambridge University Press, New York, pp. 589–607.

Knäuper, B., Carrière, K., Frayn, M., Ivanova, E., Xu, Z., Ames-Bull, A., et al., 2018. The Effects of if-then plans on weight loss: results of the McGill CHIP healthy weight program randomized controlled trial. Obesity 26, 1285–1295. https://doi.org/10.1002/oby.22226.

Knoll, N., Hohl, D.H., Keller, J., Schuez, N., Luszczynska, A., Burkert, S., 2017. Effects of dyadic planning on physical activity in couples: a randomized controlled trial. Health Psychol. 36, 8–20. https://doi.org/10.1037/hea0000423.supp.

Loyen, A., van der Ploeg, H.P., Bauman, A., Brug, J., Lakerveld, J., 2016. European sitting championship: prevalence and correlates of self-reported sitting time in the

28 European Union member states. PloS One 11, e0149320. https://doi.org/10.1371/journal.pone.0149320.
Lüscher, J., Hohl, D.H., Knoll, N., Scholz, U., 2019. Invisible social support and invisible social control in dual-smoker couple's everyday life: a dyadic perspective. Ann. Behav. Med. 53, 527–540. https://doi.org/10.1093/abm/kay062.
Luszczynska, A., 2006. An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. Soc. Sci. Med. 62, 900–908. https://doi.org/10.1016/j.socscimed.2005.06.043.
Luszczynska, A., Schwarzer, R., 2020. Changing Behavior Using Social Cognitive Theory. In: Hagger, M., Cameron, L., Hamilton, K., Hankonen, N., Lintunen, T. (Eds.), The Handbook of Behavior Change. Cambridge University Press, Cambridge, pp. 32–45. https://doi.org/10.1017/9781108677318.003.
Luszczynska, A., Sobczyk, A., Abraham, C., 2007. Planning to lose weight: randomized controlled trial of an implementation intention prompt to enhance weight reduction among overweight and obese women. Health Psychol. 26, 507–512. https://doi.org/10.1037/0278-6133.26.4.507.
Maher, J.P., Conroy, D.E., 2015. Habit strength moderates the effects of daily action planning prompts on physical activity but not sedentary behavior. J. Sport Exerc. Psychol. 37, 97–107. https://doi.org/10.1123/jsep.2014-0258.
Matthews, C.E., Moore, S.C., Sampson, J., Blair, A., Xiao, Q., Keadle, S.K., et al., 2015. Mortality benefits for replacing sitting time with different physical activities. Med. Sci. Sports Exerc. 47, 1833–1840. https://doi.org/10.1249/MSS.0000000000000621.
Michie, S., Ashford, S., Sniehota, F.F., Dombrowski, S.U., Bishop, A., French, D.P., 2011. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALORE taxonomy. Psychol. Health 26, 1479–1489. https://doi.org/10.1080/08870446.2010.540664.
Owen, N., Healy, G.N., Dempsey, P.C., Salmon, J., Timperio, A., Clark, B.K., Goode, A.D., Koorts, H., Ridgers, N.D., Hadgraft, N.T., Lambert, G., Eakin, E.G., Kingwell, B.A., Dunstan, D.W., 2020. Sedentary behavior and public health: integrating the evidence and identifying potential solutions. Annu. Rev. Publ. Health 41, 265–287. https://doi.org/10.1146/annurev-publhealth-040119-094201.
Prescott, S., Traynor, J.P., Shilliday, I., Zanotto, T., Rush, R., Mercer, T.H., 2020. Minimum accelerometer wear-time for reliable estimates of physical activity and sedentary behaviour of people receiving haemodialysis. BMC Nephrol. 21, 230. https://doi.org/10.1186/s12882-020-01877-8.
Prestwich, A., Conner, M.T., Lawton, R.J., Ward, J.K., Ayres, K., McEachan, R.R.C., 2012. Randomized controlled trial of collaborative implementation intentions targeting working adults' physical activity. Health Psychol. 31, 486–495. https://doi.org/10.1037/a0027672.
Prestwich, A., Conner, M.T., Lawton, R.J., Ward, J.K., Ayres, K., McEachan, R.R.C., 2014. Partner- and planning-based interventions to reduce fat consumption: randomized controlled trial. Br. J. Health Psychol. 19, 132–148. https://doi.org/10.1111/bjhp.12047.
Quante, M., Kaplan, E.R., Rueschman, M., Cailler, M., Buxton, O.M., Redline, S., 2015. Practical considerations in using accelerometers to assess physical activity, sedentary behavior, and sleep. Sleep Health 1, 275–284. https://doi.org/10.1016/j.sleh.2015.09.002.
Radtke, T., Luszczynska, A., Schenkel, K., Biddle, S., Scholz, U., 2018. A cluster randomized controlled trial comparing the effectiveness of an individual planning intervention with collaborative planning in adolescent friendship dyads to enhance physical activity (TWOgether). BMC Publ. Health 18. https://doi.org/10.1186/s12889-018-5818-6.
Rollo, S., Prapavessis, H., 2020. A combined Health Action Process Approach and mHealth intervention to increase non-sedentary behaviours in office-working adults—a randomised controlled trial. Appl. Psychol. Health Well Being 12, 660–686. https://doi.org/10.1111/aphw.12201.
Sallis, J.F., Owen, N., 2015. Ecological models of health behavior. In: Glanz, K., Rimer, B. K., Viswanath, K.V. (Eds.), Health Behavior: Theory, Research, and Practice, fifth ed. Jossey-Bass/Wiley, Hoboken, pp. 43–64.
Sasaki, J.E., John, D., Freedson, P.S., 2011. Validation and comparison of ActiGraph activity monitors. J. Sports Sci. Med. 14, 411–416. https://doi.org/10.1016/j.jsams.2011.04.003.
Scholz, U., Berli, C., Lüscher, J., Knoll, N., 2020. Dyadic behavior change interventions. In: Hagger, M., Cameron, L., Hamilton, K., Hankonen, N., Lintunen, T. (Eds.), The Handbook of Behavior Change. Cambridge University Press, Cambridge, pp. 622–648. https://doi.org/10.1017/9781108677318.043.
Schroé, H., Van Dyck, D., De Paepe, A., Poppe, L., Loh, W.W., Verloigne, M., Loeys, T., De Bourdeaudhuji, I.D., Crombez, G., 2020. Which behaviour change techniques are effective to promote physical activity and reduce sedentary behaviour in adults: a factorial randomized trial of an e- and m-health intervention. Int. J. Behav. Nutr. Phys. Activ. 17 https://doi.org/10.1186/s12966-020-01001-x.
Schwarzer, R., Luszczynska, A., Ziegelmann, J.P., Scholz, U., Lippke, S., 2008. Social-cognitive predictors of physical exercise adherence: three longitudinal studies in rehabilitation. Health Psychol. 27, 54–63. https://doi.org/10.1037/0278-6133.27.1(Suppl.).S54.
Sheeran, P., Webb, T.L., 2016. The intention-behavior gap. Soc. Personal. Psychol. Compass. 10, 503–518. https://doi.org/10.1111/spc3.12265.
Silva, M.A.V.d., São-João, T.M., Brizon, V.C., Franco, D.H., Mialhe, F.L., 2018. Impact of implementation intentions on physical activity practice in adults: a systematic review and meta-analysis of randomized clinical trials. PloS One 13, e0206294. https://doi.org/10.1371/journal.pone.0206294.
Skotte, J., Korshøj, M., Kristiansen, J., Hanisch, C., Holtermann, A., 2014. Detection of physical activity types using triaxial accelerometers. J. Phys. Activ. Health 11, 76–84. https://doi.org/10.1123/jpah.2011-0347.
Spittaels, H., Van Cauwenberghe, E., Verbestel, V., De Meester, F., Van Dyck, D., Verloigne, M., Haerens, L., Deforche, B., Cardon, G., De Bourdeaudhuij, I.D., 2012. Objectively measured sedentary time and physical activity time across the lifespan: a cross-sectional study in four age groups. Int. J. Behav. Nutr. Phys. Activ. 9, 149–160. https://doi.org/10.1186/1479-5868-9-149.
Tremblay, M.S., Aubert, S., Barnes, J.D., Saunders, T.J., Carson, V., Latimer-Cheung, A. E., et al., 2017. Sedentary behavior research network (SBRN) – terminology consensus project process and outcome. Int. J. Behav. Nutr. Phys. Activ. 14, 1–17. https://doi.org/10.1186/s12966-017-0525-8.
van der Ploeg, H.P., Hillsdon, M., 2017. Is sedentary behaviour just physical inactivity by another name? Int. J. Behav. Nutr. Phys. Activ. 14, 1–8. https://doi.org/10.1186/s12966-017-0601-0.
World Health Organization, 2010. Global Recommendations on Physical Activity for Health, 2020. https://www.who.int/publications/i/item/9789241599979. (Accessed 1 December 2020).
World Health Organization, 2020. Health 2020. Guidelines on Physical Activity and Sedentary Behaviour. https://apps.who.int/iris/bitstream/handle/10665/336656/9789240015128-eng.pdf?sequence=1&isAllowed=y. (Accessed 1 December 2020).
Zhang, C.Q., Zhang, R., Schwarzer, R., Hagger, M.S., 2019. A meta-analysis of the health action process approach. Health Psychol. 38, 623–637. https://doi.org/10.1037/hea0000728.